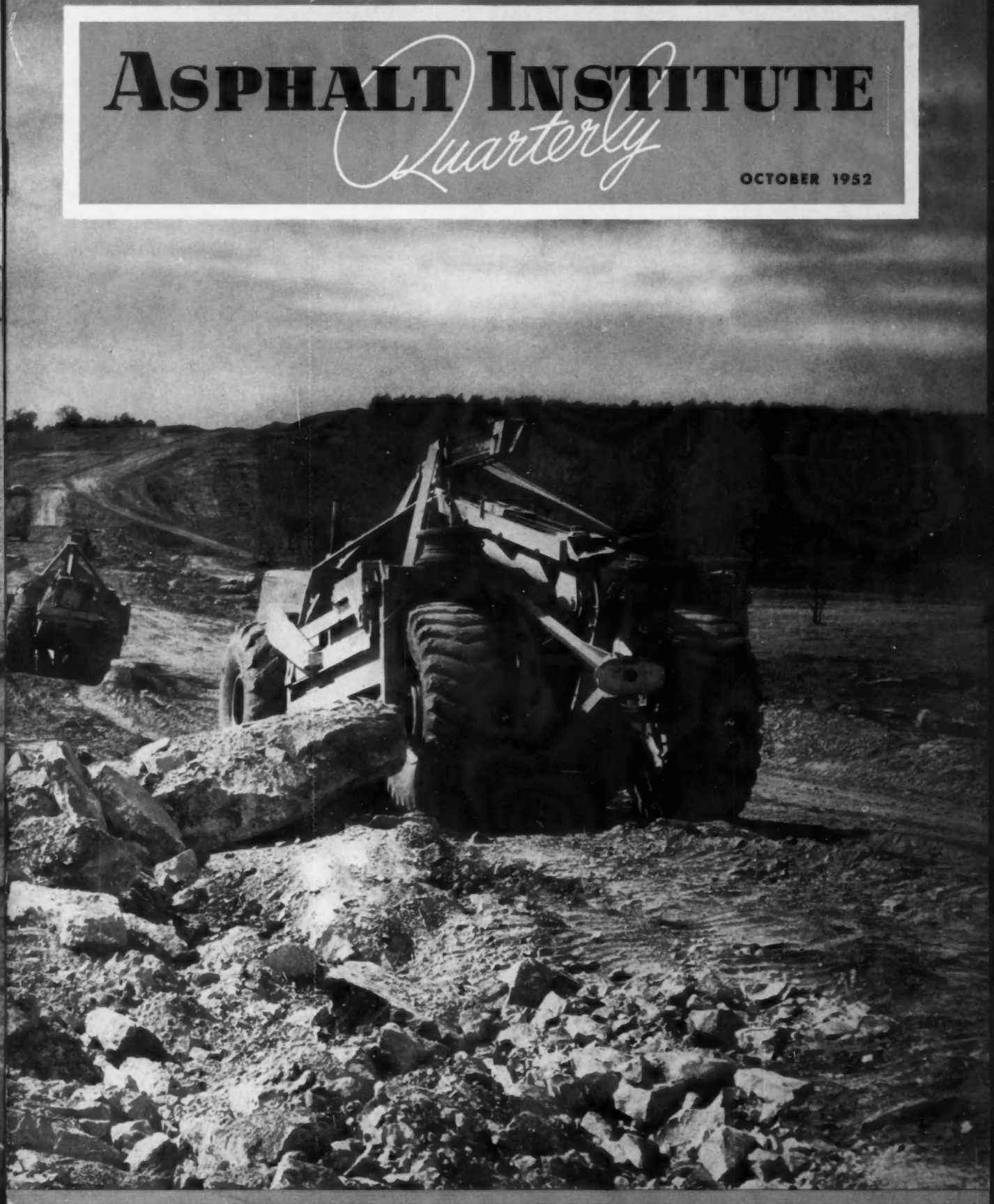
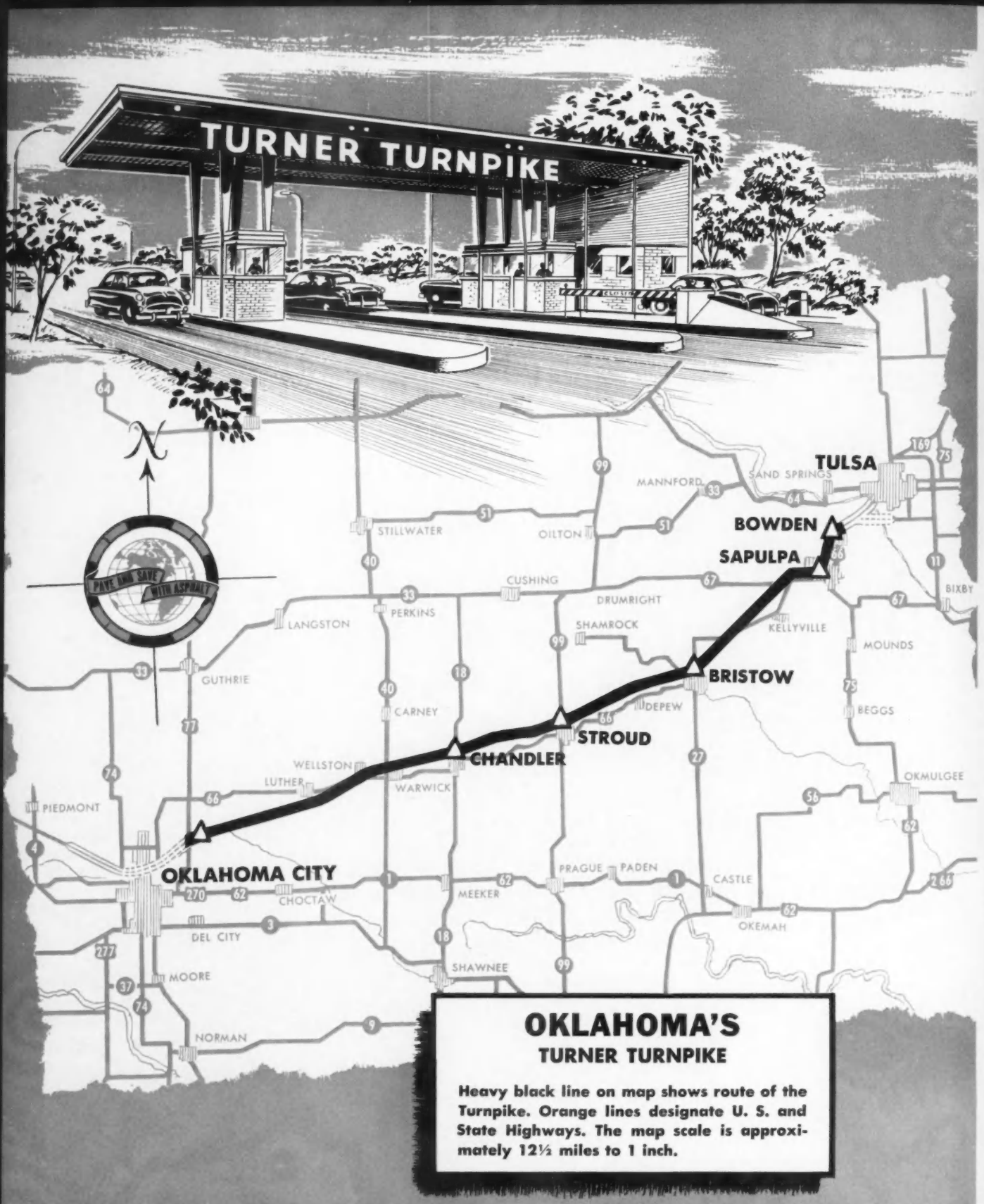
ASPHALT INSTITUTE *Quarterly*

OCTOBER 1952





OKLAHOMA'S
TURNER TURNPIKE

Heavy black line on map shows route of the Turnpike. Orange lines designate U. S. and State Highways. The map scale is approximately 12½ miles to 1 inch.

ASPHALT INSTITUTE Quarterly

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The names of the Member Companies of the Institute, who have made possible the publication of this magazine, are listed herein on page 15.

EDITORS

Bernard E. Gray, *President of The Asphalt Institute*
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COVER

Featured on the covers is a picture taken by Hugh Wallace, February 20, 1952, showing heavy grading work on the Turner Turnpike, near Bristow. Both loose and solid rock were encountered in many cut sections but the high-speed, giant, earth-moving equipment shown made rapid, economical construction on a large scale possible. It is a rugged step past the blue print stage in constructing a modern turnpike.

The map opposite shows the Turner Turnpike route in relation to U.S. and State Highways. With extensions at both ends this project contributes a highest-type, 120-mile throughway from east of Tulsa to west of Oklahoma City. The caption drawing of a proposed Toll Station is presented through the courtesy of the Oklahoma Turnpike Authority.

EDITORIAL

The Oklahoma of today has become a veritable empire, and yet a large part of its growth has taken place within the life-time of many of its present inhabitants. The very place where Oklahoma City the capital now stands was opened to settlement only in 1889, when on April 22nd, there was enacted one of the most dramatic episodes of all time. President Harrison had signed an Act some months before whereby the lands (now comprising a number of counties) formerly Indian reservations were declared to be public domain and open for settlement. By that April morning, literally thousands of land-hungry settlers had lined up at the border and, at the appointed signal, dashed forward to stake their respective claims. Every kind of vehicle, ox-drawn, horse-drawn, some even hand-hauled, took off across the prairie in that mad dash; yet within a few weeks thereafter new farm lands were being plowed and a new state was in the making to add further lustre to the national union. Blessed with great material resources of petroleum, grain, cotton, cattle, mines and forests, Oklahoma, most important of all, still retains the pioneer spirit of those first settlers who were not afraid to pit their strength against unknown dangers for the sake of a brighter future.

Now, like the rest of America, Oklahoma faces a new kind of problem. With our great resources, plus an extraordinary technological development, it has become possible to provide increasing food supplies yet with ever-decreasing numbers of people on the farms. For good or ill, this has meant a steady increase in numbers of those who live in cities, until today more than half of all the people are residents in communities of 2,500 or more. In Oklahoma two cities in particular, Tulsa and Oklahoma City, have had phenomenal growth. Where but sixty years ago only a handful of people dwelt, the population in these metropolitan areas now has grown to nearly 600,000. These cities which, with shining towers, greet the visitor as he approaches across the plains are but a promise of what he finds when he enters their gates. Wide streets, attractive stores, libraries, museums and civic centers, are all tributes to the building ability of their people.

With all the nation's expansion in both farm and industrial wealth, there has grown too the difficulty of easy exchange between producer and consumer. At first the railroads, with horse-drawn travel at terminals, seemed an answer. The development of the *internal combustion engine,* however, and its use not only in cars and trucks, but also in farm tractors, electric light plants and power development, has completely changed that old order which existed when Oklahoma became a state in 1907.

Today there are more people, but also there is the potentiality of more food and more goods to supply their needs. The pressing problem of the moment is how producers can have these products transported from place of production to place of use; and do so at costs that will be reasonable as compared to the cost of the users making the goods themselves. One of the easiest and quickest ways is over the highway, and so today the modernization of our highway system to meet these new requirements is one of our most important jobs. Traffic between Oklahoma City and Tulsa having become too great to be satisfactorily accommodated by existing roads, the people decided to do something about it and, as in the building of the cities themselves, the new Turner Turnpike, now under construction between them, will represent *the very best in design and construction.*

Photo Wallace

STATE CAPITOL AT OKLAHOMA CITY SURROUNDED BY OIL DERRICKS

OKLAHOMA'S TURNER TURNPIKE

by

HUGH A. WALLACE — Division Engineer

and

JAMES C. JOHNSON — District Engineer

The Asphalt Institute

Oklahoma, one of the younger states — and one of the most modern — began taking its place in history in 1889 when a part of the Indian Territory was opened up for settlement. Its famous land rush of homesteaders, which began at noon April 22, 1889, was the beginning of the settlement of the western part of the state. From this land rush Oklahoma obtained its nickname "The Sooner State" because there were some settlers, unaccustomed to strictly legal restrictions, who slipped in ahead of the homesteaders and staked claims to choice areas of land. These early arrivals were known as "Sooners".

In 1907 the Indian Territory and Oklahoma Territory were combined and the State of Oklahoma admitted to the Union with its capital located at Guthrie. As more settlers began to pour in and it appeared that Oklahoma City would become its leading metropolitan center, the state capital was moved there in 1910, where its Capitol Building is now appropriately surrounded by oil derricks.

Within two blocks of the business district of Bartlesville, Oklahoma's first commercial oil well was completed April 15th, 1897 and since that time oil has played a major role in the growth of many cities in Oklahoma, more particularly Tulsa and Oklahoma City. Each of these two are capital cities, Oklahoma City being the state capital of Oklahoma, and Tulsa is rightfully known as the "Oil Capital of the World". Oil production, which had its beginning in Oklahoma in 1897, mounted to 150,861,008 barrels of crude oil for the year 1950 and is increasing at a steady rate. This one industry, which had a record annual payroll of $242,639,960.00 in that year, has meant much in the fast-developing economy of the state.

PROVIDING ADEQUATE ROADS

Although Oklahoma has outstanding wealth in the oil industry, this state has something in common with the majority of the other states in that there are insufficient public funds for the complete modernization and construction of a highway system to meet the demands of present-day motor transportation. To alleviate this condition to some extent, Governor Roy J. Turner asked the Oklahoma Legislature in 1947 to pass the necessary legislation for a Turnpike Authority which would be empowered to construct a toll road parallel or near to the present U. S. Highway 66 between Oklahoma City and Tulsa. The primary purpose of this toll road was to provide a modern highway between these two cities, not only because U. S. 66 was wholly inadequate but also because, at the normal rate of new construction, it would be many years before a modern free highway could be built.

The Toll Road Act was passed by the Legislature creating the Oklahoma Turnpike Authority, to be governed by four appointed members and the Governor, as an ex-officio member, to act on all matters concerning the construction and operation of the toll road. The law, as passed, provided that this road be located within one-half mile of Sapulpa, Bristow, Stroud and Chandler, the four principal cities on U. S. Highway 66 between Tulsa and Oklahoma City.

Turnpike Authority members appointed by Governor Turner were J. Wylie Richardson of Oklahoma City as Chairman, and R. P. Matthews of Sapulpa, Joe Jarboe of Tulsa and Paul Wilson of Stroud as Members. The Authority then appointed H. E. Bailey, former Director of the Oklahoma Highway Department, as General Manager of

the Turnpike Authority, W. D. Hoback, formerly Urban Engineer of the Oklahoma Highway Department, as Chief Engineer, and Leon Shipp as General Counsel.

Because bond market conditions were unfavorable in 1948, financial complications were encountered and the Turnpike Authority was unable to sell its bonds at a reasonable rate of interest. In 1949 an application was made for an RFC loan but this application was not approved. Early in 1950, however, the bond market took a turn for the better and turnpike bonds were then sold to a group of New York investment companies at a rate of 3.43% interest. In the meantime, the Turnpike Authority had employed DeLeuw, Cather & Company as consulting engineers who subcontracted the engineering work on portions of the Turnpike to various engineer firms in Oklahoma City and Tulsa. As soon as funds were made available for construction these engineer firms immediately began preparing plans and specifications and the first contract for grading and drainage structures was awarded on December 19, 1950. On the following day, Governor Roy J. Turner turned the first dirt with a gold-plated shovel presented to him for the occasion.

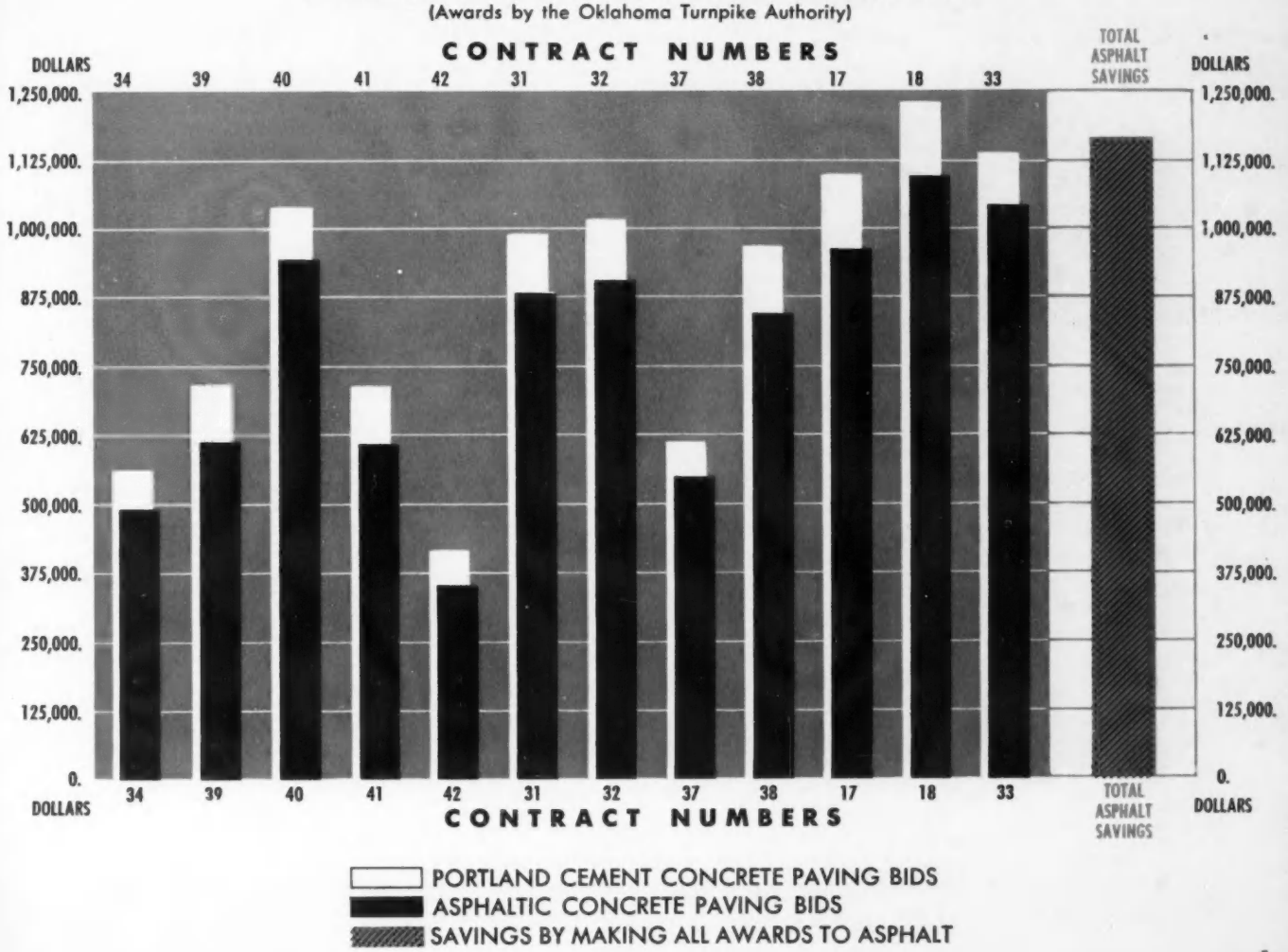
Upon the completion of his term of office, January 9, 1951, Governor Turner was suceeded by Governor Johnston Murray, who has taken a very active and effective part in the Turnpike Authority affairs. The term of Turnpike Authority Member Paul Wilson having expired, Governor Murray appointed Glen R. Key of Chandler as his successor. Early in Governor Murray's administration, a controversy arose in regard to the selection of paving materials for the Turnpike. In this connection, Governor Murray had two important aims in mind: first, that great pains be taken to assure that the toll road be built on a truly competitive basis as economically as possible; and second, that the project be completed at the earliest practicable date to start producing revenue for retirement of the bonds.

Paving materials competition resulted in the Turnpike engineers requesting bids on five alternate designs, three of which were for a flexible type pavement and two for a rigid type. The lowest paving bids submitted were for a flexible type consisting of a 5" hot-mix hot-laid asphaltic concrete pavement on a 7" stabilized aggregate base course. All paving awards were made on this Alternate.

The placing of the first hot-mix asphaltic concrete on the Turnpike was on the Tulsa-Sapulpa section, August 12, 1952, with paving starting on several other sections shortly thereafter. The scheduled completion date of the various paving contracts and opening of the Turnpike is February 1, 1953. Toll fares for passenger cars travelling the entire length of the Turnpike have been tentatively set at $1.25 per vehicle with truck fares ranging from $1.65 to $3.30.

Turner Turnpike Competitive Bidding Chart

(Awards by the Oklahoma Turnpike Authority)



DESIGN AND CONSTRUCTION OF THE TURNPIKE

By Hugh A. Wallace and James C. Johnson

COMPACTION OF FILL MATERIAL BY SHEEPSFOOT ROLLERS *Photo: Wallace*

The Turner Turnpike is a modern, four-lane, divided highway, paved with high-quality, hot-mix asphaltic concrete. It connects the two principal cities of Oklahoma; Tulsa and Oklahoma City, reducing the present total distance of 122 miles to 108.5 miles, of which 86.3 miles will be Turnpike. Located near the present U.S. Highway No. 66, it will bypass all intermediate cities. There will be J-loop interchanges at Chandler, Stroud, Bristow and Sapulpa. At each end, this modern expressway will connect with newly constructed bypasses at both Oklahoma City and Tulsa, allowing either for entrance into each city or for through traffic to avoid them.

GENERAL FEATURES

The minimum right-of-way width on this project is 200′, fenced on both sides. The overall width of roadway, including the 15′ median strip, is 87′. Dual lane pavements on each side of the median strip are 24′ wide and shoulders outside of the pavements are 12′ in width.

Lines and grades are such as to allow safe travel at speeds in excess of 70 miles per hour. The maximum degree of curvature on this modern thoroughfare is only 1°30′ and there are only three curves of this maximum. All other curves are 0°30′ or less. The horizontal curves are all super-elevated for a design speed of 70 miles per hour. The minimum sight distance for both horizontal and vertical curvature is 700′, considering the eye height at 4½′ and a 4″ height of object on the pavement surface. The PC-PT sag verticals are limited to a minimum of 400′ and a maximum of 1,000′ and profile tangents are not less than 500′. The minimum and maximum gradients are 0.3% and 3.0% respectively. J-loop interchanges will be spirally curved, with a minimum radius of curvature of 250′. Driving lanes will be of a 12′ minimum width.

CONTRACT LIMITATIONS

Legislation establishing the Oklahoma Turnpike Authority specifically limited the value of contracts for grading, bridges and paving which could be awarded as a single contract. Grading contracts were limited to a maximum of $500,000 each, whereas bridge contracts and paving contracts were limited to a maximum of $1,000,000 each. There were 26 separate grading contracts, usually of 2 to 5 miles each in length. A lesser number of paving contracts were required, usually running from about 4 to 8 miles in length.

ALTERNATE PAVEMENT DESIGNS

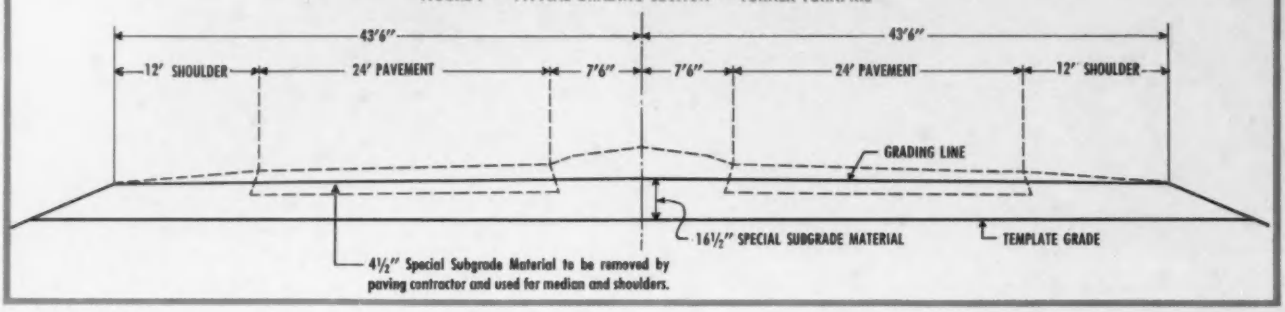
Paving plans were prepared by DeLeuw, Cather and Company, consultants to the Oklahoma Turnpike Authority. These plans contained five alternate sections of pavement each designed and checked by the most modern and approved design formulas to satisfactorily withstand the specified axle loading of 28,800 pounds. The alternate sections are briefly described as follows:

Alternate 1 — This alternate consisted of an 8″ portland cement concrete pavement on a 4″ sand cushion. Pavement contraction joints were spaced 20′ apart and expansion joints were required only at points 20′ beyond bridge approach slabs. The contraction joints included suitable dowel bars and spacers. Longitudinal joints contained ½″ round, deformed bars, 2½′ in length and spaced 2½′ center to center. A small amount of reinforcement was provided at the corners of the slabs.

Alternate 2 — This alternate consisted of a 9″ portland cement concrete pavement on a 3″ sand cushion. Expansion joints were provided only at points 20′ beyond bridge approach slabs. Contraction joints were also provided but only the first five such joints adjacent to expansion joints contained dowel bars and spacers. Longitudinal joints included ½″ round, deformed bars, 2½′ in length and spaced 2½′ center to center. There was no reinforcement in the slab corners.

Alternate 3 — This alternate consisted of a 5″ hot-mix asphaltic concrete pavement and 7″ of stabilized aggregate

FIGURE I — TYPICAL GRADING SECTION — TURNER TURNPIKE



base. The 5" pavement consisted of 2" of wearing course and 3" of binder or leveling course.

Alternate 4 — Alternate 4 comprised 6" of hot-mix asphaltic concrete pavement on 6" of stabilized aggregate base. The 6" asphaltic pavement consisted of a 2" layer of wearing course and two 2" layers of leveling course.

Alternate 5 — This alternate required 8" of hot-mix asphaltic concrete pavement on a 4" stabilized aggregate base. The 8" pavement contained a 2" wearing surface and three 2" layers of leveling course.

From the above summaries it may be noted that the total thickness of base and pavement was 12" in all five alternates. These alternates comprised the basis of bids for the paving contracts.

SUBGRADE REQUIREMENTS

Each alternate paving section required a zone of improved subgrade, identical for all alternates. The thickness of improved subgrade was dependent upon the bearing capacity of in-place materials and was determined in accordance with the following criteria:

Case 1 — If material having a C.B.R. of 5 or less and a P.I. of more than 20 is encountered at template grade in cuts, it shall be removed to a depth of 12 inches below template grade. No such material shall be placed higher than 12 inches below template grade in fills. The roadbed from 12 inches below template grade to template grade shall be built up with materials having a C.B.R. of 6 or more and a P.I. of less than 20; from template grade to 6 inches above template grade with materials having a C.B.R. of 8 or more and a P.I. of less than 10; and from 6 inches above template grade to the grading line with Special Subgrade Materials.

Case II — If the material at template grade to a depth of more than 12 inches below template grade has a C.B.R. of 6 to 7 and a P.I. of 10 to 20, the roadbed shall be built up to 6 inches above template grade with materials having a C.B.R. of 8 or more and a P.I. of less than 10 and from 6 inches above template grade to the grading line with Special Subgrade Materials.

Case III — If the material at template grade to a depth of more than 6 inches below template grade has a C.B.R. of 8 or more, and a P.I. of less than 10, the roadbed shall be built up from template grade to 6 inches above template grade with materials which are equal to or better than the materials of template grade and from 6 inches above template grade to the grading line with Special Subgrade Materials. Special Subgrade Materials shall conform to the requirements of the Special Provisions of the Specifications.

The term "Template Grade" may be defined as the surface elevation of the common grading prior to placement of improved subgrade materials. "Grading Line" may be defined as the surface elevation of improved subgrade material as constructed by the grading contractor, being 16½" above the template grade in all cases. These terms are further demonstrated on a generalized cross section shown in Figure 1.

The final thickness of special subgrade material is 12" within the pavement limits except as noted for Case 1. The contractor, however, is required to place the special subgrade material to a depth of 16½" above the template grade, it subsequently being trenched to a depth of 4½" below the grading line by the paving contractor to receive the base. Material from the trench is used to build up the median strip and shoulder as illustrated on Figure 1.

All subgrade materials for a depth of 6" below the template grade are being compacted to 95% of standard AASHO density (AASHO Designation T99-49) and materials below that elevation are compacted to 90% of standard density. All special subgrade materials are compacted to 95% of standard density.

Continued on page 8

GRADING OPERATIONS WITH HEAVY EARTH MOVING EQUIPMENT
Photo: Oklahoma Turnpike Authority

Spreading and blending stabilized aggregate base course materials *Photo: Wallace*

TABLE I

TABULATION OF THEORETICAL LOAD CAPACITY
OF TURNER TURNPIKE
BASE AND PAVING SECTIONS

	Alt. No.	Pavement	Pavement Thickness	Base Thickness	Theoretical Wheel Load
Westergaard Formulae	1	P.C.C.	8″	4″	15,100 lbs.
	2	P.C.C.	9″	3″	14,500 lbs.
Sheet's Formulae	1	P.C.C.	8″	4″	15,600 lbs.
	2	P.C.C.	9″	3″	15,700 lbs.
O. J. Porter Curves	3	A.C.	5″	7″	15,000 lbs.
(California Bearing Ratio)	4	A.C.	6″	6″	15,000 lbs.
	5	A.C.	8″	4″	15,000 lbs.
O. J. Porter Curves	3	A.C.	5″	7″	21,000 lbs.
Modified By	4	A.C.	6″	6″	22,000 lbs.
D.M. Burmister's Equation	5	A.C.	8″	4″	24,500 lbs.
	3	A.C.	5″	7″	16,000 lbs.
McLeod's Curves	4	A.C.	6″	6″	16,500 lbs
	5	A.C.	8″	4″	17,500 lbs.
	3	A.C.	5″	7″	14,700 lbs.
Kansas Tri-Axial Method	4	A.C.	6″	6″	15,000 lbs.
(Single Tire)	5	A.C.	8″	4″	15,800 lbs.

LOAD BEARING CAPACITY

The legal loading limit for the State of Oklahoma is 18,000 pounds per axle. The Turner Turnpike, however, has been designed for a basic axle loading of 24,000 pounds plus a 20% impact factor, resulting in a total design axle load of 28,800 pounds.

The theoretical load bearing capacity of the five alternate paving sections, including special subgrade materials as described, was determined by the consulting engineers, based on several widely used paving thickness design formulas. The load bearing capacity thus determined for each paving alternate and for each of the several design formulas are shown in Table 1.

This tabulation shows load-supporting capacity in terms of "wheel load" rather than by axle loading as specified. The allowable axle loading, however, is usually considered to be twice the wheel load and thus all paving alternates are indicated to be entirely adequate for the design axle load of 28,800 pounds (wheel load of 14,400 pounds). In fact, some formulas indicate a supporting capacity for flexible pavement alternates considerably in excess of that required.

PAVEMENT DESIGN SELECTED

Paving contracts were awarded in all instances to the low bidder which in each case was for Alternate 3. A typical section of this pavement is shown on Figure 2, further illustrated by a photographic cut at the right of the section.

Subgrade requirements, the same for all alternates, were as previously set forth. A 7″ stabilized aggregate base course was required for the selected Alternate 3. Alternate gradations of this base material are shown in Table II as follows:

TABLE II

GRADATION OF STABILIZED AGGREGATE BASE MATERIAL

Sieve Size (Square Opening)	TYPE A	TYPE B PERCENT PASSING
3″	—	—
2″	—	100
1½″	—	70-100
1″	100	55-85
¾″	70-100	50-80
⅜″	50-80	40-70
#4	35-65	30-60
#10	25-50	20-50
#40	15-30	10-30
#200	5-15	5-15

(1) The Plus No. 4 size material shall have a minimum of 40% crushed.

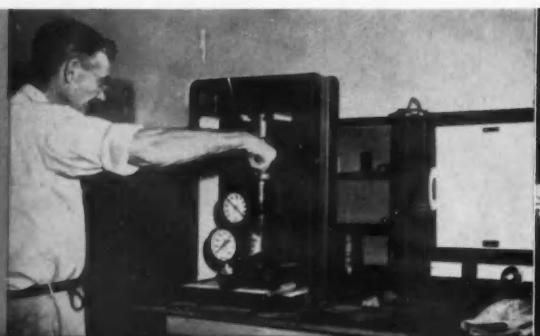
(2) Coarse aggregate shall have Los Angeles' Abrasion below 50.

(3) Material passing the #200 sieve shall not be greater than ⅔ the material passing the #40 sieve.

(4) Material passing #40 sieve shall have a Plasticity Index not to exceed 8, and a liquid limit not to exceed 28.

The stabilized aggregate base course was constructed by placing it in two layers and compacted to not less than 95% of standard AASHO density. The bottom layer extended 27′10″ and the top layer 25′6″ on each side of the median strip.

The pavement for the selected Alternate 3 consists of 5″ of hot-mix asphaltic concrete. The 3″ leveling course is designated as black base and meets the gradation requirements shown in Figure 3 on page 10 for Type "A" aggregate. The 2″ surface course is composed of aggregates meeting the gradation requirements shown in Figure 4 on page



(Left) Molding asphaltic concrete specimen by Texas Gyratory Method

(Right) Testing stabilized aggregate base material

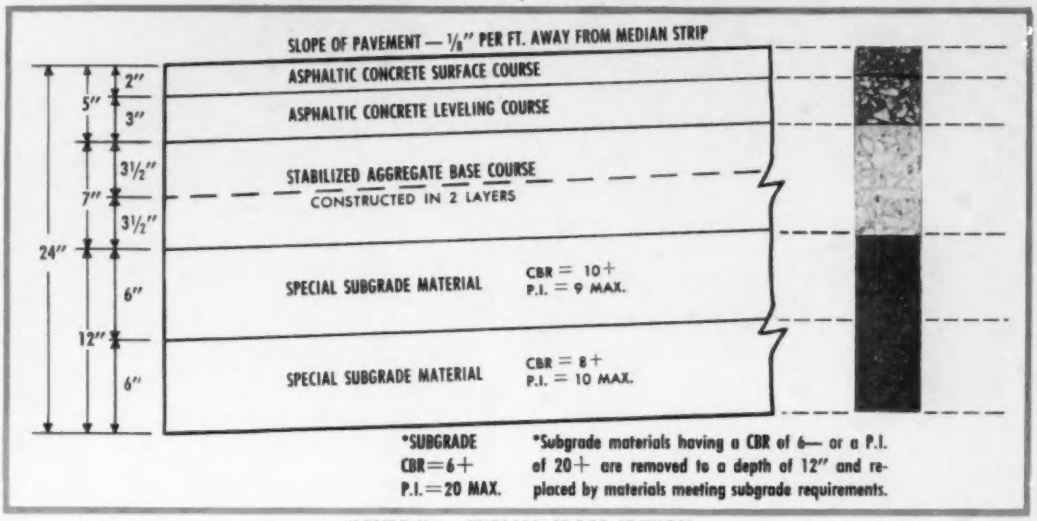


FIGURE II — TYPICAL CROSS SECTION

10 for Type "B" aggregates. Minimum and maximum asphalt contents are 4.5 and 6.5 percent respectively for the leveling course mixes and 5.0 and 7.0 percent respectively for the surface course mixes. Job-mix formulas have presently been established for 9 of the paving contracts. The ranges of aggregate gradation and asphalt content for these mixes are also included in Figures 3 and 4.

A Hveem stability value of 40 was specified as minimum for both surface and leveling course mixes. The initial trial mixes provided Hveem stability values in excess of 60. Adjustments were therefore made in job-mix formula gradations by reducing percentage of material between the No. 10 and No. 40 sieve together with a slight increase in asphalt content, in order to improve workability. Efforts were made to limit the maximum Hveem stability to a value of 55. Job-mix formulas for the 9 sections noted above have provided an average Hveem stability of 53.5 for the surface course.

SHOULDERS AND MEDIAN STRIP

Provision was made to construct shoulders and the median strip of special subgrade material, trenched from the subgrade as previously discussed and illustrated in Figure 1. The median strip is 15′ wide and will be sodded.

Shoulders are required only adjacent to the outer lanes. They are 12′ in width and sloped 5/8″ per foot on the surface. The basic shoulder design required asphalt stabilization of the soil to a depth of 6″ and for the full 12′ width of the shoulder. Further, the full 12′ is to be covered with a single bituminous surface treatment.

Two additional alternates were allowed for shoulder construction with the proviso that no additional charge would be made to the Turnpike Authority. One alternate provided for a 6″ compacted depth of stabilized aggregate, the same as used in construction of the base course. The other alternate called for a 6″ depth of plant-mix soil asphalt with either (Road Mixes) MC-2, MC-3, or MC-4; or (Plant Mixes) MC-4 or MC-5 cutback asphalt. A single bituminous surface treatment on the full 12′ was also required on both shoulder alternates.

MISCELLANEOUS STRUCTURES

The size of opening of all drainage structures was based upon the best available weather records in conjunction with Talbot's formula. A 4′ minimum height of fill and pavement structure above the top of the culvert was required over all pipe and box culverts. Before placing pipe culverts, the soil is compacted to an elevation one foot above the proposed top of pipe and for a distance of 20′ on either side of the pipe location. A trench, 3′ wider than the pipe, is then excavated, the pipe installed, and backfill is compacted by mechanical means.

All Turnpike bridges and U.S. highway cross-over bridges are designed in accordance with AASHO H-20, S-16 standards. Cross-over bridges carrying state road traffic are designed by AASHO H-20 standards and county road cross-overs by H-15 standards. A minimum clearance of 15′ at the outer edge of the pavement was maintained for all structures.

CONSTRUCTION PROCEDURE

The subgrade was compacted to 90% of standard AASHO density to an elevation 6″ below the template grade and to 95% of standard density for the remaining 6 inches. It was then smooth graded to an elevation which was 24″ below that of the finished pavement surface. The "special subgrade material" was then placed and compacted in accordance with procedures previously discussed.

The construction of the special subgrade affords a striking example of obtaining increased foundation strength at no extra cost by proper engineering surveys, studies, and planning. Soil profiles were prepared for each cut section to determine the quality and amount of soils available for fill and special subgrade construction. By proper selection and blending of these higher bearing value excavated soils it has been thereby possible to obtain suitable materials for the special

Continued on page 10

Adding Crusher-Run Limestone for blending later with additional soil binder *Photo: Wallace*

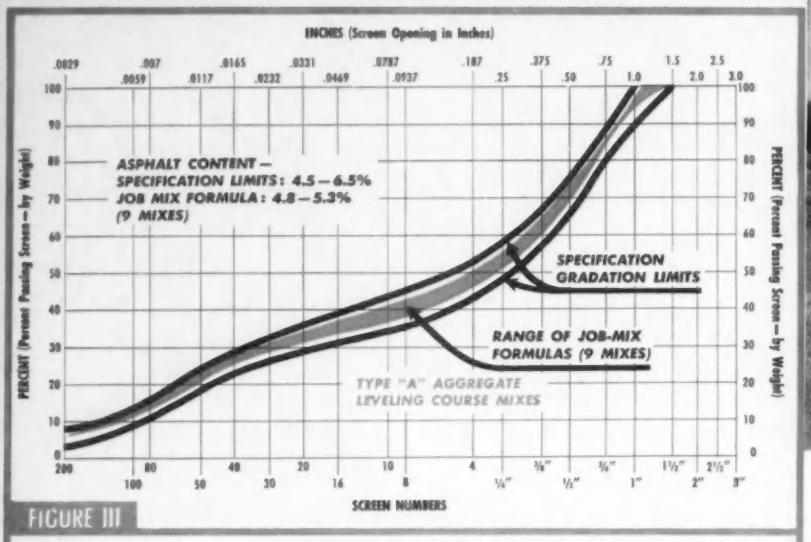

INCHES (Screen Opening in Inches)
.0029 .007 .0165 .0331 .0787 .187 .375 .75 1.5 2.5
.0059 .0117 .0232 .0469 .0937 .25 .50 1.0 2.0 3.0
ASPHALT CONTENT —
SPECIFICATION LIMITS: 4.5 — 6.5%
JOB MIX FORMULA: 4.8 — 5.3%
(9 MIXES)
SPECIFICATION GRADATION LIMITS
RANGE OF JOB-MIX FORMULAS (9 MIXES)
TYPE "A" AGGREGATE LEVELING COURSE MIXES
PERCENT (Percent Passing Screen — by Weight)
200 80 40 20 10 4 ⅜" ¾" 1½" 2½"
100 50 30 16 8 ¼" ½" 1" 2" 3"
SCREEN NUMBERS

FIGURE III

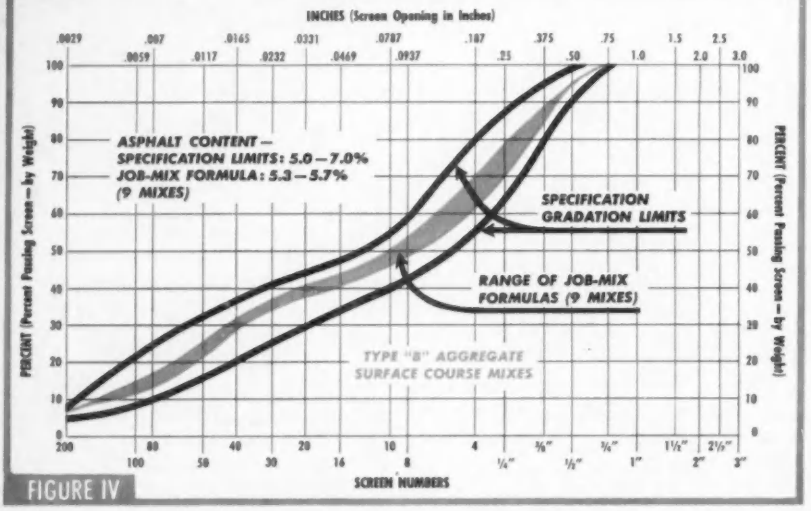

INCHES (Screen Opening in Inches)
.0029 .007 .0165 .0331 .0787 .187 .375 .75 1.5 2.5
.0059 .0117 .0232 .0469 .0937 .25 .50 1.0 2.0 3.0
ASPHALT CONTENT —
SPECIFICATION LIMITS: 5.0 — 7.0%
JOB-MIX FORMULA: 5.3 — 5.7%
(9 MIXES)
SPECIFICATION GRADATION LIMITS
RANGE OF JOB-MIX FORMULAS (9 MIXES)
TYPE "B" AGGREGATE SURFACE COURSE MIXES
PERCENT (Percent Passing Screen — by Weight)
200 80 40 20 10 4 ⅜" ¾" 1½" 2½"
100 50 30 16 8 ¼" ½" 1" 2" 3"
SCREEN NUMBERS

FIGURE IV

Compacting first 3½" course of stabilized aggregate base *Photo: Wallace*

subgrade over a substantial portion of the Turnpike. In certain areas, however, it has been necessary to obtain borrow excavation from nearby sources for the special subgrade. It is interesting to note that borrow excavation averaged only about $0.29 per cubic yard whereas unclassified roadway excavation, including some rock cut, averaged about $0.33 per cubic yard. The excavation price includes a 500′ free overhaul, but watering and compaction are extra-pay items.

Except for solid rock excavation, embankment material is placed in loose layers of not more than 6″, watered, blended and compacted to the required density. The moisture content of the soil is carefully controlled to provide for proper compaction at or near the optimum moisture content of the soil. Particular attention is given to the compaction of embankment materials adjacent to structures. Whenever the material is not thoroughly compacted by conventional rolling equipment, mechanical tampers are used to provide the required density.

STABILIZED AGGREGATE BASE

Although specifications for the stabilized aggregate base require only 40 percent of plus No. 4 size aggregate, the paving contractors are using 50 to 80 percent of this material and the use of type B aggregate has been predominant. The coarse stone is first spread in the trenched area of the special subgrade. Fine material is then spread on the stone and the two are intimately mixed. Sufficient water is added to assist in mixing operations. Samples of the blended materials are then obtained for appropriate laboratory tests. *If a single test, in a group of tests made on a section, does not meet specification requirements, the entire section must be reprocessed and laboratory tests rerun until all tests meet specification requirements. No borderline materials are accepted.* The base is then compacted to at least 95 percent of standard AASHO density. Compaction, however, is generally exceeding 97 percent of standard density. The base is placed at a rate of about 115 tons per 100′ station per 24′ width. Sheepsfoot rollers are used for initial compaction, followed by pneumatic-tired and steel-wheel rollers.

ASPHALT PAVEMENT SURFACE

The pavement surface is 24′ wide on each side of the median strip, sloping ⅛″ per foot toward the outside edge. The 3″ black base or leveling course is placed in a single layer to a width of 24′6″. The center line joints of the black base and surface course are offset at least 6″ and usually the offset distance is nearer 9 inches. Both the black base and the surface course pavements are being compacted to at least 96 percent of laboratory density and to not less than 92 percent of theoretical density.

The surface tolerance on pavement finish is ⅛″ in 10′. This tolerance is continually checked by a three-wheel Buzz-O-Meter having a 10′ span between the front and rear wheels. A floating center wheel is designed to ring a bell when high or low spots exceed the allowance tolerance. Careful checking with this instrument allows for the correction of any irregularities during construction.

All shoulder areas, except those in Contract No. 34 are being prepared in accordance with the basic design calling for 6″ of in-place soil asphalt stabilization, surfaced with a single bituminous surface treatment. Shoulder areas included in Contract No. 34, however, are being constructed of stabilized aggregate base course material, surfaced with a single bituminous treatment.

During the steel strike it appeared that eleven of the bridges would have to be redesigned for pre-stressed concrete beams in place of steel beams. Adequate steel was obtained, however, and bridges are being constructed with steel beams as originally planned.

Construction of the Turner Turnpike is progressing well in accordance with schedules, and this modern thoroughfare should be open to traffic early in 1953.

The Oklahoma Turnpike Authority's

HIGHWAY MAINTENANCE STUDY

Reviewed by WALTER F. WINTERS
Chief Engineer, The Asphalt Institute

Building low maintenance cost into the Turner Turnpike: Using hot-mix pavers to place 3" asphaltic concrete leveling course *Photo: Wallace*

The Oklahoma Turnpike Authority at the outset was confronted with many problems incidental to policies and plans which were to govern in the construction of the Turner Turnpike. Because of economic considerations the necessity to call for alternate bids on rigid and flexible pavements was obvious and, on March 27, 1951, turnpike engineers were instructed to proceed accordingly. When the comparative designs discussed in the preceding article were approved for bid, the idea was advanced from some quarters that although bids on the rigid pavement might exceed those of flexible, there might possibly be a saving over a period of years for the rigid type because maintenance on the flexible pavement might be higher. Consequently, the question of *comparative maintenance costs* of the two types became of prime importance to the Turnpike Authority. Numerous maintenance figures were submitted from outside sources but there were so many discrepancies in the data that it was decided to have the Turnpike Authority make *its own* maintenance study and H. E. Bailey, General Manager, was so instructed.

On October 12, 1951 Mr. Bailey submitted his Maintenance Report. Many important findings of interest to Highway Engineers are contained in this study, but probably the most cogent consideration is the fact that this report, because the data is very recent, pertains principally to *the effect of post-war traffic and heavy trucking on the maintenance of rigid and flexible type pavements.* This heavier loading vitally affects every highway department, because today's high maintenance costs can be traced to the excessive traffic using the highways, a condition which may get worse instead of better.

Mr. Bailey requested maintenance cost data from seventeen states and fifteen of them are included in his report, ten of which submitted comparative data. These ten states were carefully selected with reference to their range in geographical location, volume and type of traffic, and include the following: California, Indiana, Kansas, Maine, Massachusetts, New Hampshire, Oregon, Pennsylvania, Rhode Island and Texas.

There follows on pages 12 and 13 pertinent data from the ten states submitting comparative maintenance costs.

Mr. H. E. Bailey, in his analysis of these comparative maintenance figures, pointed out that it must be realized that most states classify and keep their records differently. In other words the costs shown for portland cement concrete may include pavements varying in thickness from 6" to 10", constructed on all types of subgrade; and the costs shown for asphaltic or bituminous concrete pavements may include types of even greater variation. Some of the reports indicate that the latter type includes asphaltic concrete 1" or more in thickness on a flexible base, without differentiating between hot-mix and cold mix asphalt pavement surfaces; even including high-type, hot-mix, hot-laid asphaltic concrete of a greater thickness on a crushed stone or other flexible base, all averaged together to determine the state-wide maintenance cost per mile on the state highway system.

The various differences in cost accounting mentioned by Mr. Bailey in his report have been in existence for some time. It is a condition that must be "lived with" as it is very difficult to obtain exact uniformity among the states in the keeping of records. However, the accuracy of the state reports cannot be questioned and the overall picture portrays a very reasonable maintenance comparison of types, age and traffic conditions.

EFFECT OF MODERN TRAFFIC ON MAINTENANCE COSTS

The Portland Cement Association has issued a pamphlet entitled, "With Portland Cement Concrete Road Surface Maintenance Costs Are Less," which presents comparable maintenance costs for eight of the states listed in the "Maintenance Cost Data" table of the Oklahoma report. The average period for the Portland Cement Association data listed goes back more than eighteen years, and some of it prior to 1930. In comparing this data with the *recent* maintenance records in the Bailey Report it is found that the Portland Cement Association report, based mainly on pre-war data, shows portland cement concrete maintenance 27% less than the Asphaltic Concrete, whereas the later data as published in the Bailey Report shows **Asphaltic Concrete to be 1% less than Portland Cement Concrete, a net change favorable to asphalt of 28%.** Perhaps the conditions mentioned by Mr. Bailey account for some of this difference; however, without doubt the greatest factor in relative changes in maintenance costs is the **effect of modern traffic.**

The enormous increase *since the war* in both volume and loading of heavy trucks has had a differential damage effect on these two competitive types of pavement. The principles of asphalt flexible construction are being proved correct by modern maintenance cost records and point to the fact that heavy traffic of today and the future, must be considered in terms of *modern* design, if maximum service is to be secured with economy in both initial cost and maintenance.

Continued on page 12

OKLAHOMA ASSURES LOW MAINTENANCE COST FOR TURNER TURNPIKE, USING ASPHALTIC CONCRETE IN PLACING THIS 2" WEARING SURFACE ABOVE A 3" LEVELING COURSE.
Photo: Wallace

Continued from page 11

CALIFORNIA

The report from California includes fifty miles of portland cement concrete and thirty-five miles of asphaltic concrete which the highway department considered to be comparable in age and traffic. The past five-year average maintenance cost varied from $96.00 to $522.00 per mile per year for portland cement concrete and from $53.00 to $200.00 per mile per year for the asphaltic concrete. The five-year average for the two types was as follows:

Asphaltic Concrete .....$158.00 per mile
Portland Cement Concrete .....$261.00 per mile

INDIANA

The state of Indiana reported for the year 1949 and indicated the average cost for average annual surface maintenance was:

Asphaltic Concrete .....$167.21 per mile
Portland Cement Concrete .....$137.72 per mile

KANSAS

The Kansas report covers the maintenance costs on general types of surface for the years 1946, 1948 and 1949. The maintenance costs for asphaltic concrete in Kansas range from $109.88 to $445.85 per mile per year and Portland Cement Concrete from $561.44 to $635.76. The Bailey report quotes a weighted average annual cost:

Asphaltic Concrete .....$397.58 per mile
Portland Cement Concrete .....$607.11 per mile

MAINE

The Maine report on maintenance costs covered a period of eight and one-half years from 1942 to 1950. During this period the annual average cost of maintaining portland cement concrete ranged from a low of $61.71 per mile to a high of $443.76, while asphaltic concrete varied from a low of $48.42 to a high of $277.84 per mile. The weighted average annual maintenance cost for 8½ years in Maine follows:

Asphaltic Concrete .....$145.38 per mile
Portland Cement Concrete .....$219.45 per mile

MASSACHUSETTS

Maintenance costs for this state were submitted for the years of 1940, 1941 and 1945, since these are the latest figures available under their present system of accounting. These costs ranged from $82.88 per mile per year to $154.88 for asphaltic concrete; and from $121.36 to $242.72 for portland cement concrete, for the following average:

Asphaltic Concrete .....$117.73 per mile
Portland Cement Concrete .....$184.77 per mile

NEW HAMPSHIRE

This state reported for the years, 1948, 1949 and 1950. During this period the maintenance cost for portland cement concrete ranged from $133.68 to $149.46 and on asphaltic concrete from $74.87 to $99.73 per mile per year. The average for three years was as follows:

Asphaltic Concrete .....$ 78.77 per mile
Portland Cement Concrete .....$140.58 per mile

OREGON

The Oregon data on maintenance covers a five year period and includes maintenance costs in considerable detail. On some highways, surface maintenance cost on heavily traveled routes carrying approximately 7,000 vehicles per day was reported as low as $1.00 per mile per year for asphaltic concrete pavement in the 1946 to 1951 period. A portland cement concrete highway of the same age and traffic showed maintenance costs of $97.00 per mile per year. The five-year average maintenance costs for all portland cement concrete and asphaltic concrete highways in the State of Oregon is shown as:

Asphaltic Concrete .....$586.00 per mile
Portland Cement Concrete .....$408.00 per mile

PENNSYLVANIA

This report includes the years of 1939 to 1942 inclusive and 1947 to 1950. The Pennsylvania maintenance cost data shows a cost range of from $77.68 per mile per year to $411.69 for portland cement concrete; and for high-type asphalt pavement of from $98.13 per mile to $189.53. It is also noted in the Bailey Report that the mileage of portland cement concrete in the State of Pennsylvania decreased from 5,619 to 4,581 miles; while high-type asphalt pavement mileage was increasing from 2,020 miles to 4,099 in the reported period. The weighted average annual maintenance cost in the report is as follows:

Asphaltic Concrete .....$142.56 per mile
Portland Cement Concrete .....$192.99 per mile

RHODE ISLAND

The report from Rhode Island is for the year 1948 and lists the maintenance costs of surface repair as follows:

Asphaltic Concrete .....$220.00 per mile
Portland Cement Concrete .....$137.84 per mile

TEXAS

The data submitted from the State of Texas included a tabulation of maintenance costs for five years, namely 1945 to 1949 inclusive. In all cases this information showed that the cost of maintaining asphaltic concrete (hot-mix) was less than for portland cement concrete for the period. The average annual cost of maintenance for the five year period was:

Asphaltic Concrete .....$106.72 per mile
Portland Cement Concrete .....$153.76 per mile

The following table recapitulates the figures from the ten foregoing states, showing comparable maintenance costs as set forth in the Oklahoma Turnpike Authority's Maintenance Study:

CURRENT MAINTENANCE COST DATA
SUBMITTED TO THE
OKLAHOMA TURNPIKE AUTHORITY

STATE REPORTING	YEAR COVERED BY REPORT	AVERAGE MAINTENANCE COST FOR ASPHALTIC CONCRETE Per Mile, Per Year	AVERAGE MAINTENANCE COST FOR PORTLAND CEMENT CONCRETE Per Mile, Per Year
CALIFORNIA	1946 to 1950 incl.	$158.00	$261.00
INDIANA	1949	167.21	137.72
KANSAS	1946, 1948, 1949	397.58	607.11
MAINE	1942 to 1950 incl.	145.38	219.45
MASSACHUSETTS	1940, 1941, 1945	117.73	184.77
NEW HAMPSHIRE	1948, 1949, 1950	78.77	140.58
OREGON	1946 to 1951 incl.	586.00	408.00
PENNSYLVANIA	1939-1942 and 1947-50 incl.	142.56	192.99
RHODE ISLAND	1948	220.00	137.84
TEXAS	1945 to 1949 incl.	106.72	153.76

On a state average basis, the foregoing figures indicate an over-all average of $217.00 per mile for asphaltic concrete and $244.00 for portland cement concrete, with asphaltic concrete lower in seven out of ten states. It is interesting to note that for both the average yearly maintenance costs in most states range from $100 to $200 per mile per year. In those states where much higher costs are shown there may have been included in maintenance expenditures certain costs not directly chargeable to surface maintenance.

HAROLD J. BUCK

By the death of Harold J. Buck, on September 15th, the Asphalt Institute lost its beloved Executive Committee Chairman, who had long been ably contributing to the Institute work his wide experience in the oil industry both as an executive and an engineer.

M. O. HUNTRESS
Chairman of the Executive Committee of The Asphalt Institute

M. O. Huntress is serving as Chairman of the Executive Committee of The Asphalt Institute for the balance of the year 1952. In accordance with the Institute's practice, a representative from a member company in another division will hold this office during 1953.

Mr. Huntress joined the Allied Materials Corporation in February of 1946, as General Sales Manager. In January, 1947 he was elected Vice-President-in-Charge-of-Sales, and acts as Executive Vice-President of that Company in the absence of the Executive President.

TO AND FROM THE TURNPIKE

by M. O. Huntress

With the completion of the Turner Turnpike, scheduled for February 1, 1953, the Central and Southwestern portion of these United States will have taken a long step forward in growth, keeping pace with its neighboring sections.

Oklahoma, in its forty-five year advance "From Tepees to Towers", now has taken its first step in designing a highway for a greater load than its legally designated limit, and has selected asphaltic concrete for the heavier-duty service.

The story of the Turnpike would be far from complete without full recognition of the part played by the Highway Department of the State in providing suitable approaches and by-pass projects at each terminus of the Toll Road. The State of Oklahoma began the planning and construction of divided, four-lane highway by-pass projects near Oklahoma City and Tulsa in 1949. The Oklahoma City projects, constructed of asphaltic concrete, include approximately twelve miles into and across the north edge of the city, at a cost of more than four and one-half million dollars with at least another million dollar project planned. This by-pass project will allow westbound traffic from the Turnpike to miss the congestion of Oklahoma City traffic and regain the old route of U.S. Highway #66 near the western limits of the city.

The Tulsa by-pass, consisting of three and one-third miles of street relocation of asphaltic concrete, channels the eastbound Turnpike traffic onto the Fifty-First Street Bridge which has been constructed this year across the Arkansas River, south of Tulsa, at a cost of one and one-quarter million dollars. The entire Tulsa by-pass project has been constructed at a cost of about two and one-third million dollars, with additional projects yet to be built. With these extensions the Turnpike has in effect been lengthened into a scenic drive for a total of about one hundred and twenty miles, for the motorist to travel without delays from east of Tulsa to west of Oklahoma City.

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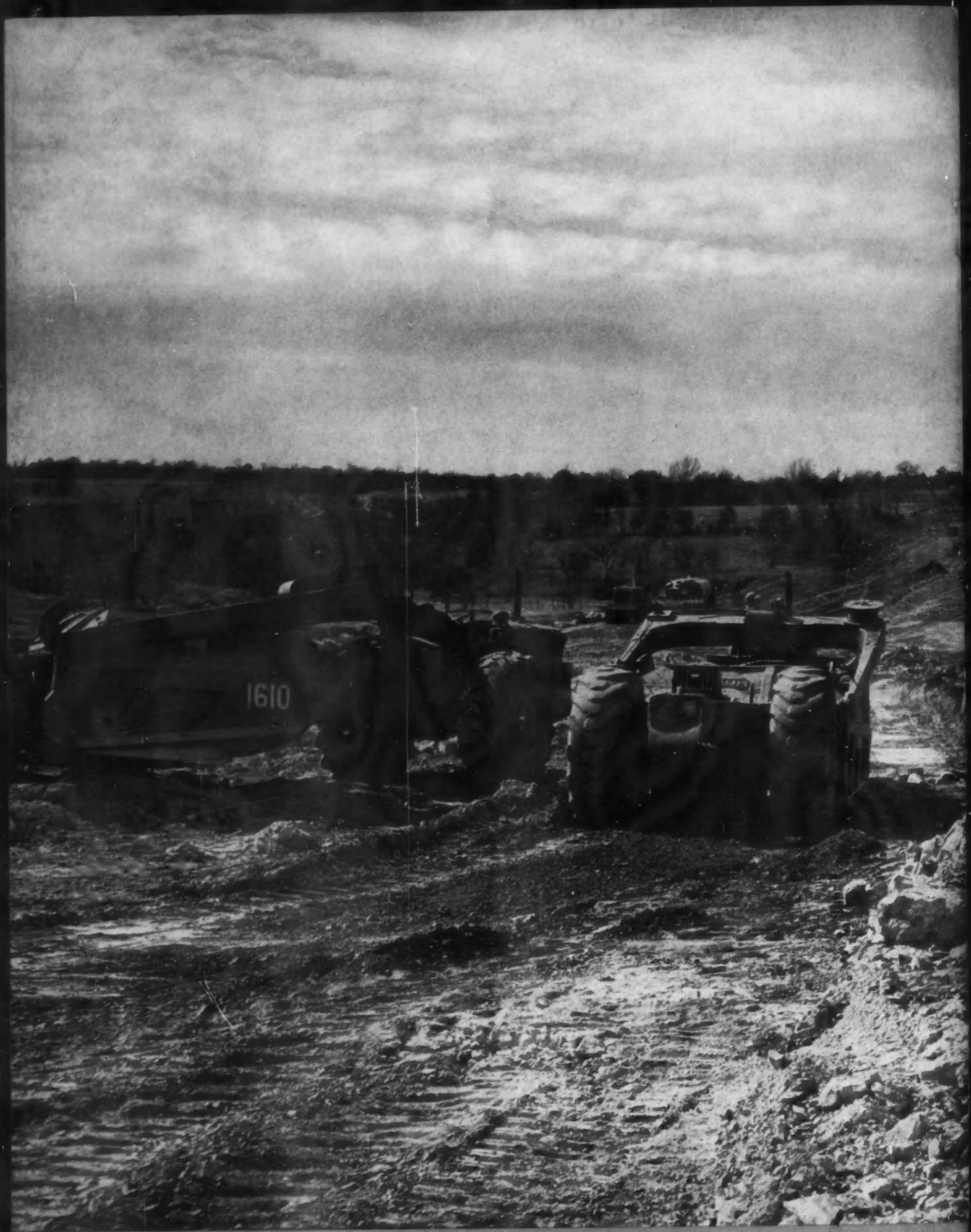
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